

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A process for making aluminosilicates of zeolite N structure comprising the steps of:
 - (i) combining a water soluble monovalent cation, a solution of hydroxyl anions and an aluminosilicate to form a resultant mixture having a pH greater than 10 and a H_2O/Al_2O_3 ratio in the range 30 to 220;
 - (ii) heating the resultant mixture to a temperature of between 50°C and the boiling point of the mixture for a time between 1 minute and 100 hours until a crystalline product of zeolite N structure is formed as determined by X-ray diffraction or other suitable characteristic; and
 - (iii) separating the zeolite N product as a solid from the mixture.
2. A process as claimed in claim 1 wherein the water soluble monovalent cation in step (i) is an alkali metal or an ammonium ion or mixtures of these ions.
3. A process as claimed in claim 2 wherein the alkali metal comprises a potassium ion.
4. A process as claimed in claim 2 wherein the alkali metal comprises a sodium ion.
5. A process as claimed in claim 2 wherein the alkali metal comprises both a potassium and sodium ion.
6. A process as claimed in claim 2 wherein the monovalent cation comprises both potassium and ammonium ions.
- 20 7. A process as claimed in any preceding claim wherein the resultant mixture of step (i) also contains a halide.
8. A process as claimed in claim 7 wherein the halide is chloride.
9. A process as claimed in any preceding claim wherein the pH of the solution of hydroxyl ions is greater than 13.
- 25 10. A process as claimed in any preceding claim wherein in step (ii) the resultant mixture is heated to a temperature of in the range 80°C to 95°C.
11. A process as claimed in any preceding claim wherein the aluminosilicate has a Si:Al ratio in the range 1.0 to 5.0.
12. A process as claimed in claim 11 wherein the aluminosilicate has a Si:Al ratio in the 30 range 1.0 to 3.0.
13. A process as claimed in claim 11 wherein the aluminosilicate is a clay.
14. A process as claimed in claim 13 wherein the clay is kaolin or montmorillonite or mixtures thereof.
15. A process as claimed in any preceding claim wherein in step (ii) said heating is 35 carried out for a time in the range 2 to 24 hours.
16. A process as claimed in any preceding claim wherein the ratio of H_2O/Al_2O_3 in the mixture of step (i) is in the range 45 to 65.
17. A process as claimed in any preceding claim wherein in step (i) a quantity of solid zeolite N is added to the mixture.

18. A process as claimed in any preceding claim wherein caustic liquor remaining in the mixture after step (iii) is re-used as at least part of a solution of anions in step (i) for subsequent production of additional zeolite N product.
- 5 19. A process as claimed in claim 3 wherein the amount of potassium utilised is governed by a ratio of K_2O/Al_2O_3 in the range 0.3 to 15.
20. A process as claimed in claim 3 wherein the amount of potassium utilised is governed by a ratio of KCl/Al_2O_3 in the range 0.0 to 15.
21. A process as claimed in claim 8 wherein the amount of chloride utilised is governed by a ratio of KCl/Al_2O_3 in the range 0.0 to 15.
- 10 22. A process as claimed in claim 4 wherein the amount of sodium utilised is governed by a ratio of Na_2O / Al_2O_3 in the range 0.0 to 2.5.
23. A process as claimed in claim 4 wherein the amount of sodium utilised is governed by a ratio of $NaCl / Al_2O_3$ in the range 0.0 to 2.8.
24. A process as claimed in claim 8 wherein the amount of chloride utilised is governed by a ratio of $NaCl / Al_2O_3$ in the range 0.0 to 2.8.
- 15 25. A process as claimed in claim 8 wherein the amount of chloride utilised is governed by a ratio of Cl / SiO_2 in the range 0.0 to 6.5.
26. A process as claimed in claim 5 wherein the amount of sodium and potassium utilised is governed by a ratio of $K/(K+Na)$ in the range 0.5 to 1.0.
- 20 27. A process as claimed in claim 5 wherein the amount of sodium and potassium utilised is governed by a ratio of $(K + Na - Al) / Si$ ratio in the range 2.0 to 18.0.
29. Zeolite N produced by the process of any preceding claim or combination of preceding claims.
- 25 30. Zeolite N produced by the process of any preceding claim having a composition according to the formula
$$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O \text{ where}$$

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cation(s) exchanged in lieu of alkali metal or ammonium

- 30 X = halide and Y is an anion and
$$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1 \text{ and } 1 \leq n \leq 10.$$
- 31. Zeolite N having a composition according to the formula
$$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O \text{ where}$$

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and
$$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1 \text{ and } 1 \leq n \leq 10$$

with the proviso that when a = 0, b = 1, c = 1, d = 0, X = Cl, M ≠ K.

32. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = alkali metal or ammonium;
P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
characterised in having a BET surface area greater than $1 \text{ m}^2/\text{g}$.

5 33. Zeolite N as claimed in claim 32 having a BET surface area between $1 \text{ m}^2/\text{g}$ and $150 \text{ m}^2/\text{g}$.

10 34. Zeolite N as claimed in claim 33 having a BET surface area between $5 \text{ m}^2/\text{g}$ and $150 \text{ m}^2/\text{g}$.

35. Zeolite N as claimed in any one of claims 32, 33 or 34 having a proportion of external surface area to internal surface area of greater than 1%.

15 36. Zeolite N as claimed in claim 35 having a proportion of external surface area to internal surface area of greater than 5%.

37. Zeolite N as claimed in claim 36 having a proportion of external surface area to internal surface area of greater than 10%.

20 38. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = alkali metal or ammonium;
P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
characterised in having an X-ray diffraction pattern which has a high background intensity of greater than 5% of a maximum peak height between the region $25^\circ < 2\theta < 70^\circ$.

25 39. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = alkali metal or ammonium;
P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
when used for exchange of ammonium ions in solution.

30 40. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

5 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$.

when used for exchange of ammonium ions in the presence of alkali metal and/or alkaline earth metal ions in solution.

41. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 \cdot nH_2O$ where

10 M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$.

15 having a cation exchange capacity ranging from 100 meq per 100g to 700 meq per 100g for ammonium ions with concentrations between less than 1 mg/L to greater than 10,000 mg/L.

42. Zeolite N as claimed in claim 41 having a cation exchange capacity greater than 200 meq per 100g.

20 43. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 \cdot nH_2O$ where

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

25 X = halide and Y is an anion and

$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

when used for exchange of metal ions in solution.

44. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 \cdot nH_2O$ where

30 M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

35 when used for exchange of metal ions in the presence of alkali metal or alkaline earth metal ions in solution.

45. Zeolite N as claimed in claim 43 or 44 wherein the metal ions comprise copper, zinc, nickel, cobalt, cadmium, silver and lead.

46. Zeolite N as claimed in claim 43, 44 or 45 having cation exchange capacity for metal ions ranging from 20meq per 100g to 400meq per 100g.

47. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
 5 M = alkali metal or ammonium;
 P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
 X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

10 when used for adsorbing ammonia gas in the temperature range 0°C to 300°C.

48. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
 M = alkali metal or ammonium;
 P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
 15 X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
 when used for adsorbing ammonia gas in the temperature range 0°C to 300°C in the presence of water.

20 49. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
 M = alkali metal or ammonium;
 P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
 25 X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
 when used for absorbing oil.

50. Zeolite N as claimed in claim 49 when used for absorbing oil greater than 50g of oil per 100g of Zeolite N.

30 51. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
 M = alkali metal or ammonium;
 P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
 35 X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
 when used for removing anions from wastewater.

52. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

5 X = halide and Y is an anion and

$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

when used in an ammonium form to have a capacity to re-exchange alkali metal ions from solutions containing hydroxyl ions ranging in concentration from 0.1 M to 2.0M.

10 53. Zeolite N as claimed in claim 52 wherein the concentration of hydroxyl ions is from 0.4 M to 1.5 M.

54. Zeolite N as claimed in claim 52 or 53 wherein the solutions containing hydroxyl ions comprise KOH or NaOH or mixtures thereof.

55. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where

M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

20 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

having a removal rate of ammonium ion ranging between 50-100% from ammonium loaded Zeolite N using a regeneration solution containing hydroxyl ions.

56. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where

25 M = alkali metal or ammonium;

P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

30 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

when used to re-exchange ammonium ions and/or to retain high selectivity for ammonium ions after regeneration with a solution containing hydroxyl ions.

57. Zeolite N having a composition according to the formula

$(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where

M = alkali metal or ammonium;

35 P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium

X = halide and Y is an anion and

$0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$

when used to kill gram positive or gram negative bacteria.

58. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = potassium or sodium or ammonium;
P = silver or zinc
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
when used to kill gram positive or gram negative bacteria.

59. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = potassium and ammonium;
P = silver and zinc
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$
when used to kill gram positive or gram negative bacteria.

10 60. Zeolite N having a composition according to the formula
 $(M_{1-a}, P_a)_{12}(Al_bSi_c)_{10}O_{40}(X_{1-d}, Y_d)_2 nH_2O$ where
M = alkali metal or ammonium;
P = alkali metal, ammonium or metal cations exchanged in lieu of alkali metal or ammonium
X = halide and Y is an anion and
 $0 \leq a \leq 1, 1 \leq c/b \leq \infty, 0 \leq d \leq 1$ and $1 \leq n \leq 10$.
where c/b is greater than 1.

15 61. Zeolite N as claimed in claim 60 wherein c/b has an upper value of 5.
20 62. Zeolite N as claimed in claim 60 wherein c/b has an upper value of 3.
63. Zeolite N as claimed in any one of claims 30-62 wherein Y is hydroxyl or halide.
25 64. Zeolite N as claimed in claim 63 wherein Y is chloride.

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